NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Proposed Acousto-Optic Filter

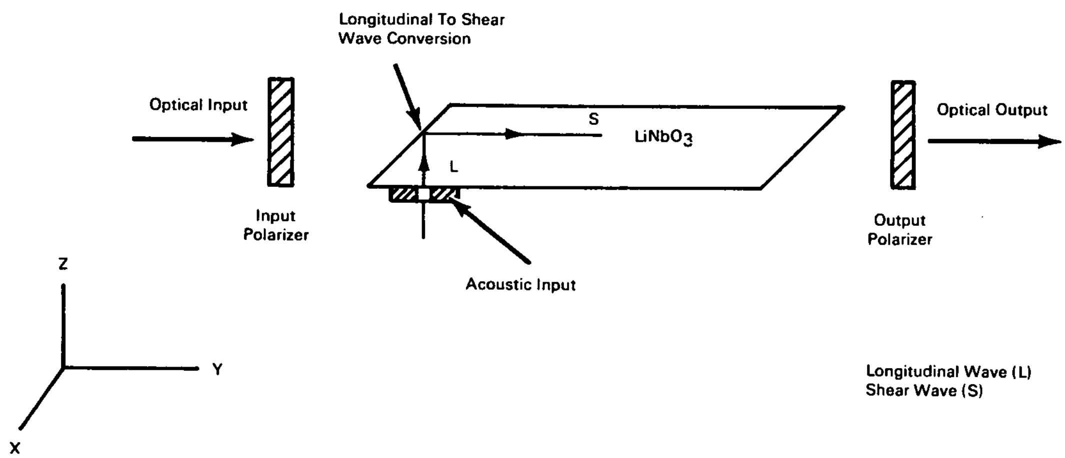

FIGURE 1. $LiNbO_3$ ACOUSTO-OPTIC FILTER.

Recent investigations suggest the possibility of a narrow band optical filter that is electronically tunable over a large wavelength region. This conceptual item should be of interest to the optical industry.

Basically, the filter would utilize collinear acousto-optic diffraction in an optically anisotropic media. The band of optical frequencies through which the filter will pass may be changed by changing the driving acoustic frequency. It is shown that a $LiNbO_3$ acousto-optic filter with a pass band approximately 1.3 cm^{-1} wide which is tunable from 4000 Å to 7000 Å should be possible by changing the acoustic frequency from 428 MHz to 990 MHz. For this case, the angular aperture will be about 1.5°, and it should be possible to attain 100% (theoretical) transmission at the filter center frequency at an expenditure of about 14 mw of acoustic power per mm^2 of filter aperture.

The proposed acousto-optic filter consists of an input polarizer, a crystal with an appropriate transducer, and an output polarizer. There exist a number of different crystal orientations, involving either longitudinal or shear waves which allow collinear diffraction of light into the orthogonal polarization. One possible configuration for the filter using $LiNbO_3$ is shown in the figure. In this case the acoustic wave is brought in as a longitudinal wave which is then converted to a shear wave upon reflection at the input face of the crystal. The acoustic shear wave and the input optical beam then propagate collinearly down the y-axis of the crystal, along which the acousto-

(continued overleaf)

optic interaction takes place. Interaction between the acoustic and optical waves takes place as a result of the photoelastic effect.

Notes:

1. Existing filters of the Lyot type are available with such narrow bandwidths and wave length tuning capabilities.
2. Probably the most severe limitation of the proposed filter is the difficulty of obtaining large apertures. Since 14 mw of propagating acoustic power is required per mm^2 of crystal aperture, a 1 cm square aperture would require an acoustic power of 1.4 watts. Broadband r-f to acoustic transducers can now be constructed with about 10 dB conversion loss, thus requiring an r-f power of 14 watts. Also, at frequencies in the 400 to 1000 MHz range, the construction of transducers having one cm^2 of area is somewhat ahead of the present state of the art.
3. Two other materials which may be used for this type of filter are sapphire and quartz. The birefringence of both of these materials is about 1/10 that of $LiNbO_3$. As a result the necessary acoustic frequencies would be centered about 70 MHz instead of 700 MHz as in the $LiNbO_3$ filter. Both the tuning rate and also the bandwidth of these filters (for the same crystal length) would be about ten times as large as that of the $LiNbO_3$ filter. The angular aperture would be about three times as large as that of a $LiNbO_3$ filter of the same length. As a result of the low refractive indices of these crystals, about ten to twenty times as much acoustic power would probably be required to obtain the theoretical 100% peak transmission. However, this might be off-set by using longer crystals.
4. This development is in a conceptual stage only; at the time of this publication no model or prototype exists. Technical inquiries may be directed to:

   Technology Utilization Officer
   Headquarters
   National Aeronautics
   and Space Administration
   Washington, D.C. 20546
   Reference: B69-10466

Patent status:

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C. 2457 (f)], to the Stanford University, Stanford, California 94305.

Source: S. E. Harris of
Stanford University
under contract to
Headquarters
(HQN-10440)